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Examining the Impact of the Engineering Successful/Unsuccessful Grading (SUG) Program on Student Retention: A Propensity Score Analysis

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Abstract

In this study, we analyzed the Successful/Unsuccessful Grading (SUG) program, an intervention that was founded at a large public university to support students during their transition into the first year of undergraduate engineering (EG) coursework. To understand how the SUG program impacts student retention of EG majors, we conducted an analysis guided by the following research questions: (a) Does participation in the SUG program have a positive impact on a student's likelihood of being retained within the College of Engineering? and (b) Does the SUG program have a differential impact for students who are underrepresented, female and minority students, in the College of Engineering? To address these inquiries, we leverage Bean and Eaton's (2000, 2001–2002) Psychological Model of College Student Retention as our theoretical framework and Propensity Score Analysis as our methodological tool. Findings provide insight for EG educational practices and future research trajectories regarding retention.

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Although legislators, educators, and employers have articulated an urgent need to expand the engineering (EG) workforce, the number of undergraduate students graduating with EG degrees continues to drop (President's Council on Jobs and Competitiveness, 2011). Examining educational interventions that boost retention rates and enhance how students experience EG curricula is an issue with far-reaching impacts on our higher education institutions and our economy. In the College of Engineering at Colorado State University (CSU), the Successful/Unsuccessful Grading (SUG) program was founded to support students during their transition into the first year of undergraduate EG coursework. Motivated by similar programs at medical schools and at EG intense schools such as MIT and Caltech, the SUG program serves two purposes: (a) reduce pressure associated with traditional grades during the first semester at CSU and (b) help students transition successfully from high school to postsecondary education.

The implementation of SUG included a series of constraints because the program was an experimental intervention, and the university leadership wanted to minimize any potential harm to student participants. To minimize any bias and maintain the valuable feedback that grades provide, faculty members were not informed on which students chose to participate in SUG. Traditional grades for the participants were changed to the S/U system by the registrar's office at the end of the semester, and students had several days to check on their *earned* grades before the conversion.

Students had the option to take either all or none of their courses using the SUG system. This choice had to be made within approximately the first two weeks of the semester to meet the state-mandated census deadline. There was no option of mixing grading schemes by a student during the semester. This structure was designed to encourage students to treat all courses the same and not use different grading schemes based on their perception of the ease or value of the course.

Finally, one of the major elements of the project allowed students the option to recover their original *earned* grades. This option was available at any time if the student changed majors outside the college and needed traditional grades for transfer purposes. For students who remained in the college, grade recovery was limited to the first 60 credit hours earned at the university.

To understand how the SUG program impacts student retention of EG majors, we conducted an analysis guided by the following research questions:

1. Does participation in the EG SUG program have a positive impact on a student's likelihood of being retained within the College of Engineering?

2. Does the SUG program have a differential impact for students who are underrepresented, female and minority students, in the College of Engineering?

To address these inquiries, this article is divided into five sections. First, we offer a brief summary of alternative grading systems. Second, we discuss how scholarship in EG education frames the notion of student retention. Third, we describe a theoretical framework that disrupts traditional models of student retention in EG education. Fourth, we describe our methodological approach for analyzing retention using propensity score analysis. Fifth, we conclude with a discussion about the results and limitations of this study, future research trajectories, and implications for EG education.

Alternative Grading Systems

Medical schools have led the way in using Successful/Unsuccessful grades to reduce stress and increase focus on learning among students who first enter medical schools. For example, in a study at the Mayo Medical School, Rohe et al. (2006) found that SUG may help reduce stress and increase cohort collaboration among medical school students in comparison with those who received traditional academic grades. At the University of Virginia medical school, a 5-year study showed that the SUG system improved student well-being and increased student satisfaction without negatively affecting academic performance (Bloodgood, Short, Jackson, & Martindale, 2009). This attention to student well-being was the original driving factor for the implementation of the SUG project. Part of being responsive to the psychological and emotional welfare of EG students included cushioning students from the effects of *grade shock* documented by Seymour and Hewitt (1997), the phenomenon where Science, Technology, Engineering, and Mathematics (STEM) majors receive significantly lower grades in their first year of college in comparison with their high school grades. At CSU, grade shock has been documented where less than a quarter of EG students who received high school grade point averages (GPAs) above 3.6 actually received college GPAs above 3.6 (Colorado State University, 2013b).

Although the benefits of this approach are not fully appreciated, it is still implemented at many medical schools. An important concern brought by Gonnella, Erdmann, and Hojat (2004) points to the loss of some "important information for identifying students in need of remedial education" when using a pass-fail grading system instead of a traditional A-F system (p. 425). The authors point out that students on the edge of needing help might get *lumped* into the pass category and therefore not identified as needing remedial help. This may be more pertinent to medical schools where students enter with a broad range of undergraduate degrees with different academic backgrounds. Other scholars have voiced concerns about the types of settings and students best suited for pass-fail grading. For example, Sgan (1970) documented how first-year students faced difficulty with pass-fail programs due to their inexperience with nontraditional grading schemes. In a separate study, Kelly and Thompson (1968) suggested that pass-fail grading schemes work most effectively for majors that are sequenced and structured in specific ways, such as STEM disciplines, whereas traditional A-F grading schemes work most effectively for majors that are flexible and modal, such as humanities and social science disciplines.

Additional concerns about pass-fail programs exist due to the possibility of losing information that identifies students in need of help, and this is legitimate both from the standpoint of the faculty, and maybe even more so for the students. If students are lulled into thinking they are performing well because of the coarseness of SUG, they might not receive the necessary formative feedback to support their learning. As described below, the conditions under which this study takes place still uses traditional grading throughout the semester, but then the SUG program effectively translates grades to SUG outcomes after the end of the semester, thus providing students with traditional grading feedback during the course.

The SUG project comprises an alternative grading system that was developed as an experimental venture at CSU. The project is available only during the fall semester of students' first year at CSU in EG. Grading throughout the semester is done in a traditional manner with faculty *blind* to who is participating in the project. After grades are submitted to the registrar's office, the grades are transformed into Satisfactory or Unsatisfactory automatically for all participants (see Gold, Reilly, Silberman, & Lehr, 1971, for a similar implementation). During the first 2 years of the project, a Satisfactory grade was assigned to any grade D or higher; during the third year, Satisfactory grades required a traditional grade of C or higher. The university grading system includes the following grades: A+, A, A−, B+, B, B−, C+, C, D, and F.

The success and ultimately the retention of EG undergraduate students continue to be a major concern to both EG programs and to society at large. Predicting and improving student success has remained an elusive goal of EG educators. Factors leading to student success, whether that means academic performance or retention in EG, are complicated and pervasive concerns in EG education.

Context of Retention in EG Education

EG education scholars, Lichtenstein, Chen, Smith, and Maldonado (2014), have articulated a difference between retention and persistence in EG literature: Retention denotes remaining within a phase, such as high school, undergraduate, or graduate school; persistence denotes progressing from one phase to the next, such as the transition from undergraduate to graduate school in EG studies. Considering how these terms have been historically conflated in the practice and scholarship of EG education, Lichtenstein et al. (2014) argue that making distinctions between retention and persistence offers a more nuanced picture of how different populations move through the EG pipeline. Using these definitions, this article focuses on retention due to our emphases on undergraduate EG education as a phase.

Two landmark studies have informed EG education about student retention (Marra, Rodgers, Shen, & Bogue, 2012). First, in their seminal work about why students leave the STEM disciplines, Seymour and Hewitt (1997) documented two types of students who tend to depart: those who become bored and those who lose self-confidence. Of the students who are retained, many tend to grow in their identities as engineers. Second, in an analysis of course-taking behaviors and college transcripts, Adelman (1998) discussed figurative *thresholds* students must traverse to succeed in EG, including an initial, yet critical period when students take entry-level STEM courses. Since then, a proliferation of STEM as well as broader educational scholarship has analyzed what *environmental* characteristics predict student retention, such as faculty engagement, teaching, advising, curriculum, and climate, as well as *student* characteristics such as demographics, motivation, precollegiate measures, and sense of belonging, to name a few (Astin, 1997; Besterfield-Sacre, Atman, & Shuman, 1997; Blickenstaff, 2005; Eris et al., 2010; Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012; Lichtenstein, McCormick, Sheppard, & Puma, 2010; Marra et al., 2012; Tinto, 1993, 2010; Walden & Foor, 2008). Whether scholars and practitioners analyze characteristics of postsecondary environments or students, the prevailing model of retention—generally in STEM and specifically in EG —is a pipeline where students leak out of different points of the pipeline (see Figure 1).

In recent years, scholars and practitioners have challenged this ubiquitous model of STEM retention. For example, the President's Council of Advisors on Science and Technology (2012) released a report that suggested replacing the pipeline model with "the image of multiple pathways" to STEM goals (p. vii). Additionally, Riley, Slaton, and Pawley (2014) critiqued higher education institutions for attempting to fix "the leaky pipeline without deeply interrogating those structures" (p. 336). To better account for institutional contexts and structures, a series of studies have emerged from the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD), a consortium that analyzes retention rates of EG students from nine universities. In one MIDFIELD study, Ohland et al. (2011) documented how varying outcomes across retention studies, due to diverse university contexts, different policies, and varying student populations, have compelled scholars and educators to consider novel approaches that strengthen postsecondary scholars' and educators' understanding of student retention (Braxton, 2000; Johnson, Wasserman, Yildirim, & Yonai, 2014). To contribute to this new generation of student retention—with increased focus on institutional context and structure—we use a model developed by Bean and Eaton (2000, 2001–2002).

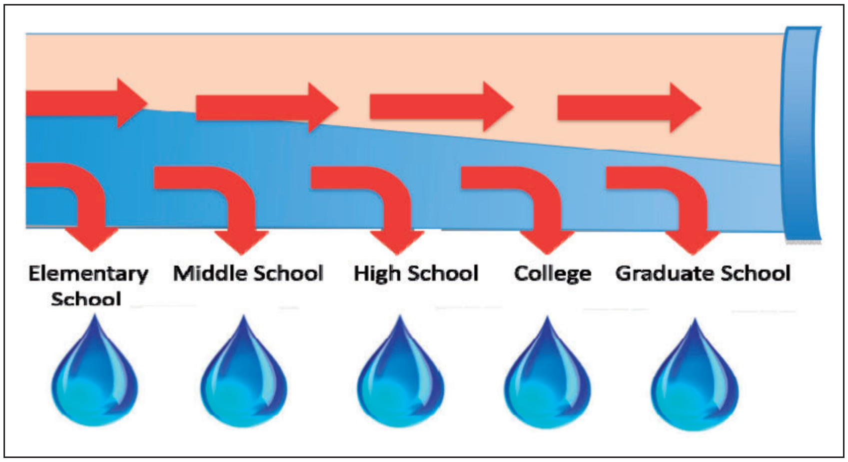

Figure 1. Leaky pipeline as a model of retention in STEM education. STEM = Science, Technology, Engineering, and Mathematics.

Theoretical Framework

Bean and Eaton's (2000, 2001–2002) Psychological Model of College Student Retention examines how the interaction between institutional contexts and individual psychological processes influence a student's decision to stay or depart. This model focuses on key entry characteristics of students, including self-efficacy, locus of control, coping behaviors, as well as precollegiate measures to operationalize prior abilities and achievements.

First, self-efficacy here denotes an individual's belief in her/his ability to carry out tasks and accomplish goals, affecting what aspirations students pursue and how much effort is expended to reach their goals (Bandura, 1997). In a literature review of multiple research studies, self-efficacy has been documented to be a significant predictor of academic performance and persistence (Rittmayer & Beier, 2009). Lent, Brown, and Larkin (1984) surveyed 42 undergraduate freshman and sophomore science and EG students about their self-efficacy and asked about the level of self-confidence they possessed to execute the responsibilities of scientists and engineers; similar to what Rittmayer and Beier (2009) found in their review, results indicated that self-efficacy predicted student persistence. In a qualitative study about the experiences of first-semester EG majors, Hutchison-Green, Follman, and Bodner (2008) analyzed how students' self-efficacy beliefs became vulnerable when comparing themselves with their peers, particularly as it relates to grades. The authors theorized that when students judged their performance to be deficient relative to their peers, they had lower EG self-efficacy and became less confident in their ability to succeed in EG. Subsequently, Hutchison-Green et al. (2008) recommended that educators design interventions to diminish the pressure, stress, and unfavorable comparisons first-semester students may encounter in EG.

Second, locus of control (Weiner, 1986) is another student entry characteristic in the model that describes the degree to which an individual perceives whether internal or external factors caused his/her circumstances. To take one example, students with an external locus of control may attribute low grades in Calculus to poor instruction, while students with an internal locus of control in the same situation may blame their insufficient exam-taking skills. After analyzing data from over 75,000 students at nine universities from 1988 to 1998, Ohland et al. (2011) hypothesized that when students performed below expectations, in general, women tend to blame themselves and leave EG, while men tend to blame outside sources and stay in EG. One interpretation of this notion suggests that women generally tend to have an internal locus of control and low self-efficacy, whereas men tend to have an external locus of control and high self-efficacy. Gaining a more internal locus of control and higher self-efficacy, then, motivates students to participate in behaviors that lead to a combination of higher retention and greater learning opportunities (Bean & Eaton, 2001–2002).

Third, coping behavioral theory (French, Rodgers, & Cobb, 1974) depicts the process through which first-year students adapt to college, which includes assessing their new surroundings and adjusting themselves accordingly to fit in and become integrated (Bean & Eaton, 2001–2002). Some healthy examples of coping with stress and adjusting to college include engaging actively in student organizations, participating in research experiences, asking questions in class, attending tutoring sessions, and forming study groups (Chen, Lattuca, & Hamilton, 2008; Gasiewski et al., 2012). In a study of 1,491 students who were surveyed about their stress levels, Johnson et al. (2014) found that the inability to cope with stress and engage with campus resources negatively impacted student grades and persistence decisions, while high levels of emotional health and the ability to productively mediate stress positively affected graduation rates.

After depicting how students enter college campuses with entry characteristics, the Psychological Model of College Student Retention illustrates how students interact with the university through "bureaucratic, academic, and social realms" (Bean & Eaton, 2001–2002, p. 75), such as financial aid, registration, professors, advisors, classmates, and other peers. By increasing sensitivity to university climate, this model encourages a paradigm shift: disrupting the notion of student retention as a leaky pipeline by reframing student retention as an interaction between students and institutional contexts.

By using the Psychological Model of College Student Retention for our theoretical framework, this study contributes to EG education research and practice in unique ways. First, very few EG studies have examined systematic interventions for which EG students can practice immediate locus of control by opting in (or out) of a program aimed to boost self-efficacy, decrease peer comparisons, reduce stress, and help students cope with transitioning to college. More specifically, when students can make choices to participate or not participate in the SUG project, they exercise locus of control. For students who choose to participate, the SUG project is intended to enhance self-efficacy and decrease stress levels. Second, educators have faced many dilemmas when trying to design first-year experiences to support and increase student success. On one hand, the difficulty of beginning calculus courses, and the resulting low pass rates, makes one consider delaying these courses until after the first semester or year to give students a chance to transition into the rigors of college academics by reducing the academic-related stress students might experience in such low pass rate courses. On the other hand, the value of integrating the math, science, and EG courses in the first year provides the benefit of students seeing the interrelated nature of these topics. The SUG project provides a rather unique opportunity to probe the questions of student success in an environment that offers a combination of both of these approaches.

Institutional Context

Because this is an institutional-level study, it is also important to ground the analysis of the impact of the program within the institutional-level context. This section describes the demographics and retention rates within the College of Engineering as well as the multivariate associations between student attributes (demographic and academic) and second-fall retention that are known from prior work at the institution. Before discussing this data, we provide a brief description of first-year EG students.

The College of Engineering maintains entrance requirements that are more rigorous than the university. Therefore, students with an interest in EG who also meet the appropriate qualifications are strongly encouraged to declare EG upon acceptance to the university. Entering first-year EG students then have the option of declaring one of the eight majors[11] in the college (Chemical & Biological Engineering, Civil Engineering, Environmental Engineering, Electrical Engineering, Computer Engineering, Engineering Science, Mechanical Engineering, and Biomedical Engineering) at entrance to the college, or can enter the college as an open-option EG student. Five introductory EG courses are taught by college faculty during the fall semester and four follow-on courses during the spring semester. Students are required to take these courses based on their choice of EG major.

College of EG Demographics and Retention Rates

Woman and minority students are underrepresented in the College of Engineering compared with their representation at the study's institution.

Figures 2 and 3 display the proportion of females and minority (respectively) students in the College of Engineering compared with the proportions across all colleges at the study's institution. These percentages are comparable with national statistics where approximately 18% of EG majors at 4-year institutions are women and 13% are minorities (National Science Foundation, National Center for Science and Engineering Statistics, 2013).

As shown in Figures 2 and 3, there are lower proportions of both female and minority students in the College of Engineering compared with the institution overall. This is not surprising within the national context of EG education. However, attracting and retaining females and minority students continues to be a priority in the college. Figure 4 displays the within-college retention rates overall and specifically among female and minority students.

Females tend to have lower retention rates. Minority students have rates that vary from being above or below the overall rate. It is important to note that minority cohort size averages around 43 students, so some of the volatility in the rate is simply due to the small cohort size. Although large and persistent gaps do not exist for female and minority students because the number of students in these subgroups is small, and the current retention rates are lower than desired, higher retention rates for these student populations is necessary to maintain reasonable sized cohorts through to graduation. Due to this focus at the college

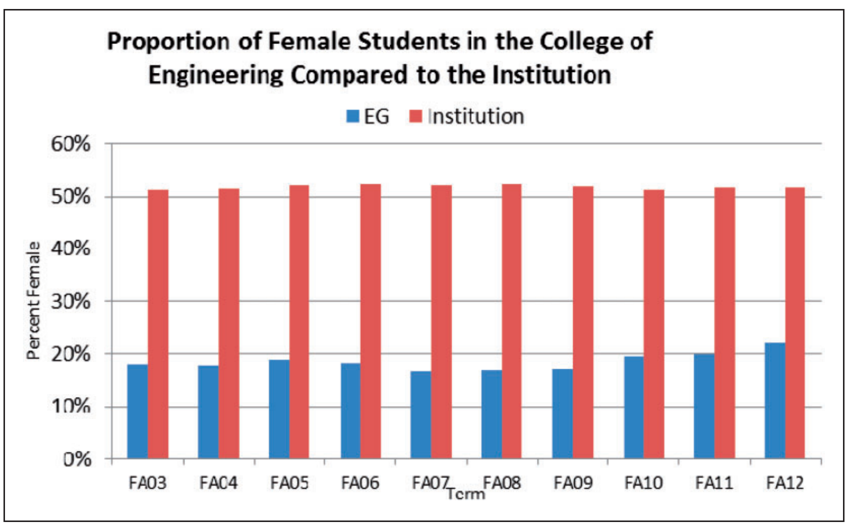

Figure 2. Proportion of female students in the College of Engineering compared with the institution. EG = engineering.

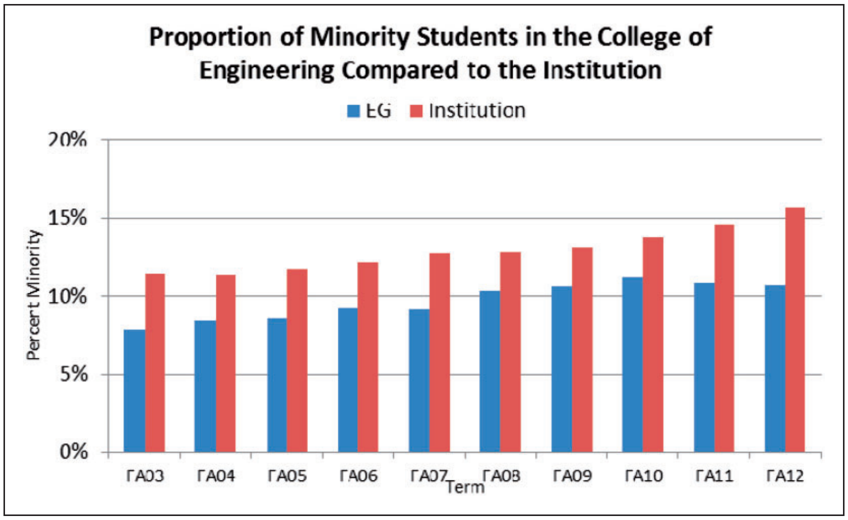

Figure 3. Proportion of minority students in the College of Engineering compared with the institution. EG = engineering.

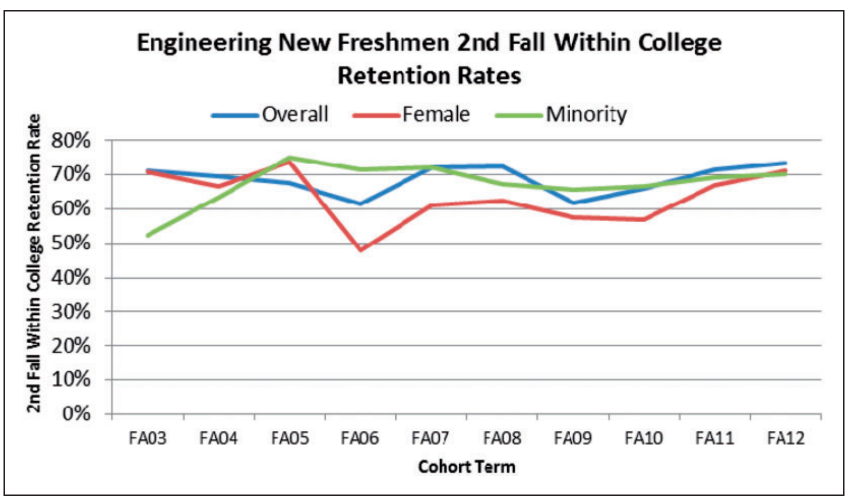

Figure 4. Engineering new freshman second fall within-college retention rates.

level, it is imperative to ask if the SUG program has differential effect for the college's underrepresented populations.

Prior Research on Student Demographics/Academics Association With Retention at Institution

Extensive multivariate analyses of the associations between student demographics and academics associations with retention at the study institution have been completed at the university level using logistic regressions (Colorado State University, 2013a). Knowledge from these studies guided the inclusion of variables in the propensity score models. In summary, these studies show that nonresidents, Pell recipients, minorities, females, and first-generation students have lower odds of retention compared with their counterparts, and higher levels of academic preparation results in higher odds of retention.

Data and Methods

This section reviews the data and methods included in the institutional-level analysis of the SUG program. To reiterate, the research questions guiding this institutional-level analysis are as follows:

1. Does participation in the SUG program have a positive impact on a student's likelihood of being retained within the College of Engineering?
2. Does the SUG program have a differential impact for students who are underrepresented, female and minority students, in the College of Engineering?

Data Sources

First-time, full-time freshmen from the FA10 through FA12 EG cohorts are included in this study. Table 1 displays the cohort sizes across program

Table 1. Count of Full-Time Freshmen by Cohort Term and SUG Participation.

	FA10	FA11	FA12	Total
Participant	138	220	293	651
Nonparticipant	298	261	278	837
Total EG cohort	436	481	571	1,488
Percent of total in program	32%	46%	51%	44%

Note. EG = engineering; SUG = Successful/Unsuccessful Grading.

participation status. Program participation status is defined by students' self-selected status at the end of their first fall semester. EG students can opt out of first-semester participation at any point prior to earning 60 credits, transferring out of the institution, or changing their major; however, for consistency, this analysis tracks participation based on the student's status at the end of their first fall semester. For the three cohorts included in this study, program participation has grown 112%, and the total EG freshman cohort size has grown about 31%. Overall, the program serves approximately 44% of first-time, full-time EG students. It is important to note that for the first year of the program, FA10, permission to implement the program was not obtained until during the first week of the semester. This reduced the time available for students to choose to participate in this program. In subsequent years, the programs was presented to entering students during the summer orientation program and allowed more time for students to consider participating in the program.

Introduction of Propensity Score Methodology

Because the research goal is to estimate a treatment effect of program participation on student success and the treatment assignment is dependent on students' self-selection, propensity score matching is an appropriate methodology (Murnane & Willet, 2011). Propensity score matching uses a logistic regression model to obtain a probability (propensity score) that the student will select into the treatment. The treatment (program participants) and control (nonparticipants) groups are created by matching students with similar propensities, which approximates random assignment. Propensity score matching allows for a comparison of statistically similar groups (participants/nonparticipants) of students with the goal of understanding what the outcome would have been for a program participant if he/she had not participated in the program (Reynolds & DesJardins, 2009).

Predictor Variables

To obtain a propensity score for the likelihood of being in the SUG program, a variety of demographic and academic variables are used in a logistic regression model that predicts SUG participation.

In terms of academic variables, the student's Colorado Commission on Higher Education (CCHE) index score, Math ACT score, and initial major/department are used. CCHE index score is a continuous variable specific to Colorado that is a measure of high school academic preparation. It is a composite score derived from high school GPA or high school rank and overall ACT or SAT test scores. More information regarding index can be found on the CCHE Web site.[22] The majority of students have a Math ACT score; however, when the ACT score is not present, the math SAT score is converted into an

ACT score using an online test score converter.[33] The EG college has eight substantively distinct undergraduate majors (housed among six different departments or schools), which are entered in the model as dummy variables with open-option students as the reference category.

The propensity score model also includes five demographic variables. Minority status is a binary variable with minority students compared with nonminority (White, unknown ethnicity, and international) students as the reference category. First-generation and Pell recipients are both compared with their respective reference group. First-generation status is self-reported and is based on the student's response to an admissions application question which asks if they are the first in their family to attend college. Pell recipient status is based on financial aid records for whether or not the student received a Pell grant their freshman year. Residency represents whether or not the student was a Colorado resident (in-state); for tuition purposes, their freshman year and resident students are compared with the reference group of nonresidents. Gender is also included as a demographic covariate. Females are compared with the reference group of males. From prior institutional-level analyses, all of these covariates are associated with retention (Colorado State University, 2013a).

Outcome Variable

The outcome variable of interest in this study is within-college retention from a student's first year to their second fall semester. Being retained within the college is measured by assessing whether the student's major at the start of their second fall semester is within EG. For instance, students are counted as not being retained when they change their major out of EG or leave the institution. To be included as a retained student, the student must maintain a major within the college at the start of their second fall semester.

Descriptive Analytical Methods

This study uses a combination of descriptive analyses to describe the demographics and academic preparation of SUG participants and nonparticipants as well as the observed retention rates. When proportions are compared, a chi-squared test is used to assess statistically significant differences, and when means are compared, a t test is used. All descriptive and inferential analyses are completed using Stata 10 (StataCorp, 2010).

Inferential Analytical Methods

The propensity score approach uses a logistic regression model to calculate the probability that a student will be in the SUG program based on a variety of academic and demographic variables. Propensity score predictor variables should be associated with either the treatment condition (EG SUG participation) or the outcome variable (persistence; Guo & Fraser, 2010; Reynolds & DesJardins, 2009). The first research question is addressed by matching on the overall matched data file; however, because the second research question focuses on determining if any differential effects exist for minority and female students, the propensity score model is run for each subgroup of students (minority, nonminority, male, and female; Reynolds & DesJardins, 2009). Table 2 contains the logistic regression coefficients for the models that predicted program participation overall and across the four different subgroups used in this study.

The associations of demographic or academic variables with program participation overall and for each subgroup of students are shown in Table 2.

Table 2. Logistic Regression Coefficients for SUG Program Participation Propensity Score.[a]

	Overall	Females	Males	Minority	Nonminority
		b (SE)[b]			
Minority	−0.25 (0.17)	−0.35 (0.31)	−0.25 (0.21)		
First generation	−0.02 (0.15)	−0.05 (0.30)	−0.03 (0.17)	0.40 (0.36)	−0.10 (0.16)
Pell recipient	−0.04 (0.15)	−0.11 (0.32)	−0.02 (0.18)	−0.20 (0.36)	0.01 (0.17)
CCHE Index	−0.03 (0.01)*	−0.04 (0.02)	−0.03 (0.01)*	−0.02 (0.03)	−0.03 (0.01)*
Math ACT score[c]	0.02 (0.02)	0.00 (0.05)	0.03 (0.02)	0.02 (0.07)	0.02 (0.02)
Resident	−0.23 (0.13)	−0.18 (0.26)	−0.25 (0.15)	0.03 (0.45)	−0.27 (0.13)
Female	−0.13 (0.13)			−0.20 (0.37)	−0.13 (0.15)
Cohort department/major[d]					
Chemical and Biological EG	−0.87 (0.22)*	−1.41 (0.44)*	−0.62 (0.27)	−1.39 (0.65)	−0.79 (0.24)*
Civil and Environmental EG	−0.45 (0.17)	−0.39 (0.36)	−0.55 (0.20)*	−0.48 (0.54)	−0.45 (0.19)
Electrical and Computer EG	−0.67 (0.21)*	−0.85 (0.57)	−0.63 (0.23)*	−1.09 (0.62)	−0.62 (0.22)*
Mechanical Engineering	−0.64 (0.16)*	−0.78 (0.40)	−0.60 (0.18)*	−0.72 (0.51)	−0.63 (0.17)*
Biomedical Engineering	−0.06 (0.21)	−0.67 (0.41)	0.24 (0.26)	−0.58 (0.60)	0.01 (0.23)
Space or Science Engineering	−0.40 (0.37)	−0.79 (0.81)	−0.30 (0.42)	0.65 (1.34)	−0.50 (0.39)
N	1,488	361	1,127	184	1,304
Likelihood ratio chi-squared, $df = 12$	55.47	25.73	38.57	10.39	47.36
Pseudo R^2	0.0272	0.053	0.0249	0.0425	0.0264

Note. EG = engineering; SUG = Successful/Unsuccessful Grading.
[a]Includes first-time, full-time Engineering students from the FA10 through FA12 cohorts.
[b]Cells display the regression coefficient with its standard error and an asterisk to indicate when $p < .01$.
[c]For students who do not have a Math ACT score, their Math SAT score is converted to an ACT score. All students with an index score have a Math ACT or SAT score.
[d]All departments/majors are compared with Engineering open-option majors.
*$p < .01$.

For instance, CCHE Index is negatively associated with program participation in the entire sample and for male and nonminority EG students. This indicates that as a student's high school academic performance increases a student's likelihood to participate in the SUG program decreases. Additionally, overall and for all subgroups of students, besides minority, at least one initial department/ major has a negative association with program participation compared with students who start as an open-option EG student. This indicates that open-option EG students are more likely to participate in the SUG program. Based on these results, program participation appears to be more influenced by academic predictors rather than demographic predictors; however, the demographic variables included in the propensity model are predictors of retention and are therefore important to include in the propensity score calculation (Guo & Fraser, 2010).

The coefficients in Table 2 are used to calculate the probability that a student will participate in the SUG program, which is used to balance the dataset by matching participants to equivalent nonparticipants. Thus, demographic/academic variables are accounted for in the inferential analysis because they are used to match program participants with similar nonparticipants. In terms of matching, this study uses one-to-one (caliper) matching without replacement with the criteria that a program participant must have a propensity score that is similar (within a quarter of a standard deviation of the subgroup's propensity score) to a nonprogram participant (Reynolds & DesJardins, 2009). Therefore, some participants and nonparticipants are excluded from the analysis because there is not a comparable student with whom to match.

A benefit of this quasi-experimental approach is that the difference in retention rates between program participants and nonparticipants among the match data is considered the average treatment effect (ATE) among the treated. This is interpreted as the difference in retention that can be attributed to the program's effect on within-college retention (Guo & Fraser, 2010). ATE can be applied to estimate the actual number of students who are retained because of the program. The estimate of students retained because of the program can also be used to assess the impact of the program on institutional retention rates. This type of causal interpretation of the ATE is not an uncommon application of propensity score analyses for program assessment at the institutional level (Keller & Lacy, 2013).

Results

The results from this institutional-level assessment of the SUG program are presented in the following two sections. First, descriptive statistics that describe the academics and demographics of program participants and nonparticipants as well as the differences in their observed within-college retention rates (prior to any propensity score adjustments) are discussed. Second, results of the propensity score analysis follow in the inferential results section.

Descriptive Results

This section describes the demographics and academic preparation of EG students. Table 3 displays the percent of students who are first-generation, Pell grant recipients, minority students, Colorado residents, or females by program participation status. Additionally, Table 3 displays the average Math ACT score and CCHE index score by participation status. Twenty-six of the students from the FA10 through FA12 EG cohorts (shown in Table 1) do not have an index score and are excluded from the analyses included in this report. The students without an index score all attended an international high school. If a student did not take the ACT, their SAT math score is converted to an ACT score. All students with an index score have an SAT or ACT score.

Generally, program participants are very similar to nonprogram participants in terms of the demographics displayed in Table 3. For instance, among the 651 program participants, 17.5% are first generation compared with 17.9% of the 837 nonparticipants. There is a slight association ($p < .1$) between participation status and gender ($\chi^2 = 2.89$) as well as participation status and minority status ($\chi^2 = 2.78$). For instance, participants have slightly smaller representation of females (22.1% compared with 25.9%) and minority students (10.8% compared with 13.6%) compared with nonparticipants. Participants do have a lower average index (122.4) score compared with nonparticipants (124.2) ($t = 3.97$) but are similar in terms of their Math ACT score.

Table 4 displays percent of participants and nonparticipants by their initial EG major/department.

EG Successful/Unsuccessful program participants are more likely to be in the EG open-option major compared with nonparticipants (22.1% and 13.4%, respectively; $\chi^2 = 10.12$), and they are less likely to be in the Chemical and

Table 3. Descriptive Statistics for SUG Participation Populations.

	Participant (651)	Nonparticipant (837)
First generation (%)	17.5	17.9
Pell recipient (%)	15.4	16.9
Minority (%)	10.8	13.6
Resident (%)	73.7	77.3
Female (%)	22.1	25.9
Math ACT (average)	27.6	27.9
CCHE (average)*	122.4	124.2

Note. SUG = Successful/Unsuccessful Grading.
*Indicates when the proportion or average is statistically different ($p < .01$) for participants compared with nonparticipants.

Biological EG department (6.9% and 11.8%, respectively; $\chi^2 = 19.63$). Otherwise, the distributions by major/department are similar between program participants and nonparticipants.

To provide additional context regarding descriptive statistics, Table 5 displays the observed within-college retention rates by program participation status for the overall population and each subgroup of interest.

Overall program participants have higher within-college retention rates compared with nonparticipants ($\chi^2 = 11.94$). For instance, 74.8% of program participants are retained within the college to the second fall compared with only 66.5% of nonprogram participants. However, this positive association is only statistically significant among the male ($\chi^2 = 9.41$) and nonminority ($\chi^2 = 12.51$) subgroups. Based on this analysis, one could conclude that there is a positive

Table 4. EG Major/Department Distributions for SUG Participation Populations.

	Participant (651)	Nonparticipant (837)
Chemical and Biological (%)*	6.9	11.8
Civil and Environmental (%)	20.1	20.1
Electrical and Computer (%)	9.2	11.6
Mechanical (%)	27.7	32.1
Biomedical (%)	11.7	8.7
Space or Science (%)	2.3	2.3
Open option (%)*	22.1	13.4

Note. SUG = Successful/Unsuccessful Grading.
*Indicates when the proportion of students in a major/department is statistically different ($p < .01$) for participants compared with nonparticipants.

Table 5. Within-College Second-Fall Retention Rate Comparisons, SUG Program Versus Nonparticipants.

	Overall	Females	Males	Minority	Nonminority
EG pass/fail program participants	74.8%	69.4%	76.3%	70.0%	75.4%
Nonparticipants	66.5%	62.2%	68.1%	67.5%	66.4%
Difference	8.3%*	7.2%	8.3%*	2.5%	9.0%*
N for participants/nonparticipants	651/837	144/217	507/620	70/114	581/723

Note. SUG = Successful/Unsuccessful Grading.
*Indicates when the proportion retained is statistically different ($p < .01$) for participants compared with nonparticipants.

association between program participation and within-college retention for male and nonminority EG students; however, this bivariate approach does not account for the demographic and academic variables that are both associated with either participating in the SUG program or retention. Therefore, a more nuanced analysis is required to infer causality between the program and outcome of interest.

Inferential Results

The descriptive results section above shows the observed retention rates among all of the students *before* applying propensity score analysis. In this section, inferential results in the tables and treatment effects are calculated among the propensity score matched data. Table 6 shows the retention rates among the propensity score-adjusted data.

The two research questions are addressed with the results shown in Table 6. As discussed in the Methodology section, these results are based on the propensity score-adjusted data file that accounts for participants' likelihood to self-select into the program. Please note the changes in sample size among the propensity score-adjusted data. For instance, there are 144 female program participants, but only 132 have a propensity score that is similar to nonprogram participants. These 132 female participants are matched to 132 similar nonparticipants to conduct the analysis.

Research Question #1

Program participation does have a positive impact on a student's likelihood of being retained within the college. Among the propensity score-matched data,

Table 6. Propensity Score-Adjusted Within-College Second-Fall Retention Rate Comparisons, SUG Program Versus Nonparticipants.

	Overall	Females	Males	Minority	Nonminority
SUG participants	75.4%	68.2%	76.5%	69.4%	75.7%
Nonparticipants	65.2%	59.1%	67.4%	67.7%	66.0%
Difference[a]	10.1% (2.6%)*	9.1% (5.9%)	9.1% (3.0%)*	1.6% (8.4%)	9.7% (2.8%)*
N for participants/ nonparticipants	601/601	132/132	451/451	62/62	535/535
Additional students retained within college	61	NA	41	NA	52

Note. SUG = Successful/Unsuccessful Grading. [a]Average treatment effect among the treated, with standard error in parentheses.
$^{*}p < .01$.

75.4% of program participants are retained within the college compared with only 65.2% of nonprogram participants. This difference of 10.1% points is statistically significant and can be attributed to the program's treatment effect rather than academic and demographic differences between participants and nonparticipants.

As discussed in the Methodology section, the ATE can be applied to the total number of typical program participants to estimate the actual number of additional students retained within-college because of the program. For instance, the 10.1% point increase in within-college second-fall retention results in approximately 61 ($.101 \times 601$) additional program participants from the FA10 to FA12 cohorts maintaining an EG major for their second fall semester. These additional 61 students contribute to the within-college retention rate discussed in the theory section of this article. The additional students retained contribute approximately 9% points to the EG's overall within-college retention rate. Thus, this program has a significant practical impact for EG's within-college retention rate.

Research Question #2

There does appear to be a differential impact of program participation for males compared with females and minority students compared with nonminority students because the retention rate difference between program participants and nonparticipants can only be attributed to program treatment effect for male and nonminority students. Table 6 shows there is a gain of 9.1% points in within-college second-fall retention for male participants and a 9.7% point gain in within-college second-fall retention for nonminority participants. The 9.1% point increase in within-college second-fall retention for males resulted in approximately 41 ($.091 \times 451$) additional male program participants from the FA10 to FA12 cohorts maintaining an EG major for their second fall semester. Similarly, about 52 ($.097 \times 535$) additional nonminority program participants from the FA10 to FA12 cohorts maintain an EG major for their second fall semester because of their program participation. Among all student populations that were analyzed in this study (minorities, females, and males), results indicate that SUG has the most significant effect for overall within-college retention rates among nonminority males. It is worth briefly mentioning that unlike many other retention intervention efforts, this project did not contain any differential aspects for various subpopulation groups. This is addressed again in the discussion section below.

The gains for females and minority students are too small with too much uncertainty to be certain that they are not due to chance. The small number of minority and female students causes the large amounts of uncertainty, which is reflected in the large standard errors associated with the treatment effects. This results in a lack of statistical power to detect differences. However, it should be noted that the treatment effect for minority students is relatively small, regardless of the large amounts of uncertainty/small sample size. Larger sample sizes might produce a statistically significant result for females; however, it is unknown if additional cohorts (i.e., larger samples sizes) will result in enough certainty to be confident that the 1.6% point difference in retention by program participation for minority students is statistically different than zero.

Discussion

Using propensity score analysis, we analyzed the effects of the SUG program on the retention of three cohorts of first-time, full-time EG freshmen who enrolled at CSU. Findings suggest that SUG participation does have a positive impact on a student's likelihood of being retained within the college, with the differential impact of program participation being higher among males in comparison with females and minority students.

Although this analysis provided initial insight about the SUG program, several limitations in this study can kindle future scholarly studies and implications for practice. The first limitation is that the selection of propensity predictors should be related, based on theory and prior research, to choosing the treatment or the outcome of interest. Extant scholarship indicates that all of the predictor variables included in this propensity score model are related to the outcome variable of interest, and the academic variables are related to program participation as well as retention. A critique of propensity score matching, however, is that the method does not serve as an effective means to reduce self-selection bias when other factors may be absent (Padgett, Salisbury, An, & Pascarella, 2010). Although the current research study includes all possible covariates in the propensity score model, for example, this study lacks measures of self-efficacy, stress, and locus of control. Although the SUG program was designed using tenets from the Bean & Eaton (2000–2001) theoretical framework where self-efficacy, stress, and locus of control play an important role in student retention, unfortunately, institutional constraints prevented us from collecting these measures. Future research studies that incorporate covariates of self-efficacy and stress can strengthen our understanding of how SUG impacts the collegiate experiences of participants.

The second limitation to this study is the small sample size among the subgroups of female and minority students. Other studies have documented that propensity score matching methods applied to smaller samples ($n < 500$) are less predictable in reducing bias (Padgett et al., 2010). For the cohorts of EG students included in this study, the propensity score model is run on subgroups with less than 500 students for two of the four subgroups (minority and female students). However, the application of propensity score matching within subgroups is the appropriate application of propensity score matching when the research question is focused on understanding if differential treatment effects exist

(Reynolds & DesJardins, 2009). Thus, the smaller sample sizes ($n < 500$) of minority and female EG students might be prohibiting the propensity score bias reduction. To boost sample sizes, the scope of this study should be expanded to include additional cohorts of students.

The third limitation to this study is the absence of qualitative methods to better understand how students experience the SUG program. Future research trajectories can integrate in-depth ethnographic studies to analyze (a) why first-year students pursue EG, (b) why participants self-select into the SUG program, (c) what environmental contexts mediate self-efficacy, stress, and locus of control, (d) whether the SUG program nurtures the development of EG identities among participants, and (e) whether different patterns of help-seeking behaviors exist between different groups. An approach that integrates both quantitative and qualitative methods can provide a richer and more detailed picture of what constitutes student retention.

This study offers important implications for EG education. With the national focus on increasing the number of EG graduates, retaining currently enrolled students can be one of the most effective approaches for boosting graduation rates. The SUG project provides an interesting lesson for improving retention of EG students. Using an alternative grading scheme for the first semester resulted in increased retention in nonminority males, the largest group of EG students. While selective institutions have used alternative grading schemes, this project showed the value of this approach in a state public institution. Grade shock among entering EG students who experience drops in GPA from high school to their first year in college is a prevalent problem (Seymour & Hewitt, 1997). The approach described herein illustrates one method for overcoming the detrimental aspects of grade shock for students. Although this project was complex in its implementation, SUG played a valuable role in reducing opportunities for students to experience grade shock. With this context in mind, other implementation schemes for reducing the impact of first-semester grades on students' persistence should be investigated.

Returning to Bean and Eaton's (2000, 2001–2002) Psychological Model of College Student Retention, this project points to the potential value of giving new EG students some sense of control over their academic success. The SUG project was completely voluntary, so students made the decision to participate or not participate. This is a very unusual level of self-determination for EG students. The context of EG education is very highly structured where a majority of courses are predetermined for the student once a major is chosen. The nonminority male students who participated in this project (the predominant majority of students in the college) showed statistically significant increases in retention. As is the case with grade shock, the results point to the value of giving students greater ownership in such a highly structured context. Future retention efforts should look for approaches that provide students with a greater *locus of control* in their programs that move far beyond simple course choices.

Related to the issue of grading schemes is the contribution of traditional grades to the culture of competition found in EG programs. As discussed above, self-efficacy is an important predictor of student retention (Rittmayer & Beier, 2009), and the self-efficacy of students becomes vulnerable when comparing themselves with others (Hutchison-Green et al., 2008). The SUG program drastically reduced the use of traditional grades and opportunities for students to conduct self-comparisons. At the end of the semester, students had limited data to make the comparisons, which enabled EG students to focus more on their own performance and less on comparing themselves with others. There is currently little discussion in the literature on interventions to protect and support the development of students' self-efficacy. Additionally, there is little discussion on the relationship between self-efficacy and stress. While eliminating traditional grades is one approach to reduce comparisons and reduce stress, other types of interventions that dilute comparisons and stress should be investigated.

There is another implication from this work that may not be so obvious. The results presented herein show statistically significant effects for the non-minority student population but no significance for minority or female student populations. At the beginning of this project, there was no effort to create concomitant support services to supplement the alternative grading scheme. Although student success education programs were not implemented for the long term, students were encouraged to use existing support services. Scholars have documented how historically marginalized populations—including first-generation college students, minority groups, and individuals with high financial need—succeed when participating in support programs that are responsive to their potential and their needs (Riley et al., 2014). This project was implemented in a manner that did not allow for this type of support. Therefore, it may not be surprising that the majority population was best served by this project. This points out a potential weakness when designing retention interventions: To impact more students, scholars and practitioners should consider differentiated support services that acknowledge the needs, circumstances, resilience, and potential of the various student populations that constitute the student population, as generic solutions probably work best for majority populations.

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Notes

1. Although there are eight majors listed, some majors are housed jointly within a department or a school (e.g., Civil Engineering and Environmental Engineering are separate majors located within the Department of Civil and Environmental Engineering).
2. Retrieved from http://highered.colorado.gov/Publications/Policies/Current/i-partf-index.pdf
3. Retrieved from http://collegeapps.about.com/od/standardizedtests/a/convert SAT2ACT.htm

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